

Kidder's collection contains examples of twenty-one species of this class, belonging to six families, namely, eleven Petrels, four Penguins, three Gulls, a Cormorant, a Duck, and a Sheath-bill. Of these, the two last-named are "the only partial vegetable feeders observed, all the other birds feeding exclusively on flesh, fish, or marine invertebrates." Of the *Chionis*, or Sheath-bills, a singular abnormal form related to the Plovers, of which there are (or were lately) living specimens in the Zoological Society's Gardens, Dr. Kidder might well have sung, in the words of the old song, "their tameness is shocking to me." "They would scarcely get out of my way," says the Doctor, "and seemed greatly interested in my movements. When I sat on a stone, keeping perfectly still, the whole party, twelve in all, came up to examine the intruder. They walked all around me, coming almost within reach; others flying up from more distant rocks to join them, and finally stopped, almost in a semi-circle, for a good stare. After watching the birds for a time, I shot four specimens, not without compunction, on account of killing such trustful acquaintances. When I walked off to get a sufficient distance away for a shot, the whole troop started to follow me, making little runs and stopping, as if filled with curiosity. I shot all four without moving from the spot, reloading for each, the birds not all flying out of range even after the gun had been fired. On subsequent occasions, various members of the party captured specimens by hand; all that was necessary to attract them within reach being to remain perfectly still. After one had been caught it served as a lure for others. When taken home alive they still showed no fear, but when let loose in the house took food readily."

Another curious fact observed is that in the absence of true birds of prey in Kerguelen's Land, the Skua of the Southern Seas (which Dr. Coues, widely departing from the ordinary binomial system designates as "*Buphagus skua antarcticus* (Les.), Coues"), appears to have taken upon itself all the habits and practices of a Buzzard or Kite. "It was at first taken for a hawk by all of us; its manner of flight, watchfulness of the ground over which it flew, and habit of perching on spots commanding a wide view, all suggested this impression. It was, indeed, difficult to believe the evidence of my own senses when I found a web-footed bird avoiding the water and preying solely, so far as my observations extended, upon other birds. When any of the party went out shooting he was pretty sure to be followed by one or two 'sea-hens,' as the sealers call them, and had often to be very prompt to secure his game before it should be carried off in his very presence."

Many details are likewise given respecting the habits of the other nineteen species observed, and great credit is due to Dr. Kidder and Dr. Coues for the speedy manner in which they have put together this interesting memoir. But what Mr. Eaton, the English naturalist at Kerguelen, and Mr. Sharp, who, we believe, has been, or is working out his birds, will say to it, we cannot tell. We fancy they will not be very much pleased at being thus forestalled.

MAYER'S RECENT ACOUSTICAL RESEARCHES¹

THIS communication is merely a preliminary note, to be followed by an elaborate paper on the above subjects. For conciseness and clearness, I present the few facts I have now to offer in the form of notes of experiments:—

¹ "On the Obliteration of one Sonorous Sensation by the simultaneous action of another more intense and lower Sound, and on the discovery of the remarkable fact that a Sound, even when very intense, cannot obliterate the sensations of another Sound Lower than it in Pitch; with Applications of these Discoveries to Measures of the Intensities of Sounds, and to the Proper Method of Conducting Orchestral Music." By Alfred M. Mayer, Ph.D., Member of the National (American) Academy of Sciences, and Professor of Physics in the Stevens Institute of Technology, Hoboken, New Jersey, U.S. America. Read before the National (American) Academy of Sciences, in Washington, April 20, 1876, and now first printed from the manuscript sent through Mr. Alex. J. Ellis, F.R.S.

Experimental Observations on the Obliteration of one Sound by another.—Several feet from the ear I placed one of those loud-ticking spring-balance American clocks, which make four beats in a second. Then I brought quite close to my ear a watch (made by Lange, of Dresden) ticking five times in the second. In this position I heard all the ticks of the watch, even those which coincided with every fourth tick of the clock. Let us call the fifth tick of the watch which coincided with one of the ticks of the clock, its fifth tick. I now gradually removed the watch from the ear, and perceived that the fifth tick became fainter and fainter, till at a certain distance it entirely vanished, and was, so to speak, "stamped out" of the watch.¹

Similar and more striking experiments were made with an old silver watch, beating four times to the second, by causing this watch to gain about thirty seconds an hour on the clock, so that at every two minutes the ticks of the watch and clock exactly coincided. When the watch was held near the ear, every one of its ticks was heard distinctly; but on gradually removing it from the ear, the ticks of the watch became fainter and fainter at the coincidences, and when the watch had been removed to a distance of nine inches from the ear, the ticks of the watch were utterly obliterated during three whole seconds of its ticks about the time of coincidence. On removing the watch to a distance of twenty-four inches, I found that I lost its ticks during nine seconds about the time of coincidence. It is here important to remark that the ticks of the clock are longer in duration, as well as lower in pitch, than those of the watches. With the watch remaining at the distance of twenty-four inches from the ear, I listened with all my attention, as tick by tick the watch approached the time of coincidence. Since the ticks of the watch are shorter in duration than those of the clock, they are overlapped by the other about the time of coincidence. Hence as, so to speak, the short ticks of the watch glided, tick after tick, under the long ticks of the clock, I perceived that more and more of the duration of each successive watch-tick became extinguished by the tick of the clock, until only the tail end of the short tick of the watch was left audible, and at last even this also crept under the long tick of the clock, and the whole of the ticks of the clock were rendered inaudible for nine seconds, at the end of which time the front or head of the watch-tick, as we may call it, protruded beyond the clock-tick, and then slowly grew up into a complete watch-tick as before. In this succession of events the tick of the old silver watch (made by Tobias) disappears with a sharp chirp, like a cricket's, and re-appears with a sound like that made by a boy's marble falling upon others in his pocket. By this experiment, therefore, a gradual analysis is made of the effect of the tick of the clock on the tick of the watch, affording a beautiful illustration of the fact that one sonorous sensation may overcome and obliterate another.

Experiments to determine the relative intensity of the Clock-ticks which obliterate three Watch-ticks.—The clock was placed on a post in the middle of an open level field in the country, on nights when the air was calm and noiseless. The ticks of the clock became just inaudible when my ear was removed to a distance of 350 feet. The ticks of the watch became just inaudible at a distance of twenty feet. The ratio of the squares of these numbers makes the ticks of the clock about 300 times more intense than those of the watch. On the same nights that I made the above determinations I also put the clock on the post, and placing against my zygomatic process a slender stick graduated to inches and tenths, I stood with my ear at distances from the clock of from eight to sixteen feet, and then slid the watch above and along the stick (taking care that it did not touch it) until it reached such a distance from the ear that its fifth tick just disappeared. Knowing the relative intensities of the ticks of clock and watch when placed at the same distance from the ear, the law of the reciprocals of the squares gives the relative intensities when the clock and watch are at the several distances obtained in the above experiments. Large numbers of such experiments have been made, and the results agree perfectly well when we take into consideration first, the difficulty

¹ The precise number of ticks in a second here mentioned are not necessary for roughly observing and understanding these phenomena. I observed them by a common American pendulum clock placed on a table, which increased the power of its half-second ticks, and a watch beating five times in two seconds. Rev. Mr. Haweis informs me that he has often noticed a similar effect at night with ordinary watches. The sensation produced by the obliteration of the tick, when the proper distance of the watch from the ear has been attained, and the consequent sudden division of the ticks into periods separated by silences, is very peculiar. It is difficult not to believe that some accident has not suddenly interfered with the action of the watch, instead of merely with our own sensations.—A. J. E.

thrown in the path of the determinations by the *gradual* fading away of the watch-ticks as they approach coincidence with the clock-ticks; and, secondly, the impossibility of arriving at any result at all, if the slightest noise (the rustle of a gentle breeze, the piping of frogs, the bark of a distant dog) should fall on the ear of the observer when engaged in making an experiment. The general result of the numerous experiments thus made shows that the sensation of the watch-tick is obliterated by a coincident tick of the clock, when the intensity of the clock-tick is *three times* that of the watch-tick. This result, however, must be regarded as merely approximative, not only from the manner in which it was obtained, but from the *complexity* of the sounds on which the experiments were made. It is interesting, however, both as being, I believe, the first determination of this kind that has ever been made, and as having opened out a new and important field of research in physiological acoustics.

Experiments on Musical Sounds.—Reserving the further development of my discoveries to a future paper, I will now briefly describe some of the more prominent and simple phenomena, which I discovered in experimenting with *musical sounds*. At the outset I will remove an objection always made by those versed in acoustics, but unacquainted with these new phenomena. It is as follows:—"You say that one sound may obliterate the sensation of another; but are you sure that the real fact is not an alteration of the *quality* of the more intense sound by the action of the concurrent feebler vibration?" I exclude this objection by experimenting as follows:—An open or closed organ-pipe is sounded forcibly, and at a few feet from it is placed the instrument emitting the sound to be obliterated, which may be either a tuning-fork on its resonance box, or a closed organ-pipe communicating with a separate bellows. Suppose that in the following experiment both tuning-fork and closed organ-pipe produce a note higher in pitch than the more intense or extinguishing sound of the open organ-pipe. Now sound the fork alone strongly, and alternately shut and open its resonance box with the hand. We can thus obtain the sound of the fork in a *regular measure of time*. When the ear has well apprehended the intervals of silence and of sound thus produced, begin the experiment by sounding the open pipe and tuning-fork simultaneously. Now, if any change is thus effected in the quality of sound emitted by the open pipe, this change cannot occur except when the pipe is sounding, and hence, if it occurs at all, it must occur in the regular measure in which the fork is sounded. The following are the facts really observed. At first every time that the mouth of the box is open, the sound of the fork is distinctly heard, and changes the quality of the note of the open pipe. But as the vibrations of the fork run down in amplitude, the sensations of its effect become less and less, till they soon entirely vanish, and not the slightest change can be observed in the quality or intensity of the note of the open organ-pipe, whether the resonance box of the fork be open or closed. Indeed at this stage of the experiment the vibrations of the fork may be suddenly and totally stopped without the ear being able to detect the fact. But if instead of stopping the fork when it becomes inaudible, we stop the sound of the open organ-pipe, it is impossible not to feel surprised at the strong sound of the fork which the open pipe had smothered and had rendered powerless to affect the ear. If we replace the tuning-fork by a closed organ-pipe of the same pitch, the results will be the same, but in this case I adjust the intensity of the higher closed pipe to the point of extinction by regulating the flow of air from the bellows, by a valve worked with a screw. The alternation of sound and silence is obtained by closing and opening the mouth of the closed pipe by the hand.

High Sounds cannot obliterate Low Sounds.—A new and remarkable fact was now discovered. No sound, even when very intense, can in the slightest degree diminish or obliterate the sensation of a concurrent sound which is lower in pitch. This was proved by experiments similar to the last, but differing in having the more intense sound higher (instead of lower) in pitch. In this case, when the ear decides that the sound of the (lower and feebler) tuning-fork is just extinguished, it is generally discovered on stopping the higher sound, that *the fork*, which should produce the lower sound, *has ceased to vibrate*. This surprising experiment must be made in order to be appreciated. I will only remark that very many similar experiments have been made, ranging through four octaves, and have been observed by a score of different ears, with the same invariable result. It is important to understand that this phenomenon depends solely on the *difference* of pitch, and not at all on the absolute pitch of the notes. Thus a feeble c'' (1024 double vibrations) is heard as

distinctly through an intense e'' (1280 double vibrations) as a feeble c (128 double vibrations) is heard through an intense g (192 double vibrations) or an intense c' (256 double vibrations).

The development of the applications and of the further illustrations of these discoveries would occupy too much space; I must therefore restrict myself to mentioning some of the most interesting. Let a man read a sentence over and over again with the same tone and modulation of voice, and while he is so doing forcibly sound a c pipe (256 double vibrations). A remarkable effect is produced, which varies somewhat with the voice experimented on, but the ordinary result is as follows. It appears as though two persons were reading together, one with a grave voice (which is found by the combination of all the real reader's vocal sounds below c in pitch, or having less than 256 double vibrations), the other with a high-pitched voice, generally squeaky and nasal, and, I need not add, very disagreeable. Of course the aspirates come out with a distressing prominence. I have observed many curious illustrations of this change in the quality of the tone of the voice, caused by the entire or partial obliteration of certain vocal components, while listening to persons talking during the sound of a steam-whistle, or in one of our long, resonant American railway carriages. Experiments similar to those on the human voice, can be made, with endless modifications, on other composite sounds, as those of reed-pipes, of stringed instruments, of running water, &c. With one of my c (128 double vibrations) free Grenié reeds, I get very marked results. Using as a concurrent sound an intense c' (256 double vibrations) I perceive the prime or fundamental simple tone c to be unaffected in intensity, while all the other partial tones (higher harmonies or overtones, as they are sometimes called) are almost obliterated, except the fifth partial (or fourth upper partial) e'' , of 640 double vibrations, and the sixth partial (or fifth upper partial) g'' (of 768 double vibrations), which come out with wonderful distinctness. The fact that the lowest, or prime partial tone in the majority of ordinary compound musical tones is the strongest, is due (among other reasons) to the fact that the sensation of each partial tone of which the whole musical tone is composed, is diminished by the action on the ear of all the components or partial tones, *below* it in pitch. Thus the higher the pitch of any component or partial tone, the greater the number of lower components which tend to obliterate it. But the prime, or lowest component partial tone, is not affected by any other. Another illustration I cannot resist giving. At the end of the street in New York, in which I now reside, there is a large fire-alarm bell, the residual sound of which, after its higher components have disappeared, is a deep simple tone. This bass sound holds its own with total indifference to the clatter of horses, or to any sounds *above* it in pitch. It dies out with a smooth gradient, generally without the slightest indentation or break produced by the other sounds of the street. Indeed in this case, as in all others where one sound remains unaffected by intense higher notes, the observer feels as though he had a special sense for the perception of the graver sound—an organ entirely distinct from that which receives the impress of the higher tones.

That one sonorous sensation cannot interfere with another which is lower in pitch, is a remarkable physiological discovery, and next after the demonstration of the fact that the ear is capable of analysing compound musical sounds into their constituent or partial simple tones, is probably the most important addition yet made to our knowledge of the nature of hearing. It cannot fail to introduce profound modifications into the hypotheses heretofore framed respecting the mechanism and functions of the ear.

Application to Orchestral Performances.—We have seen how an intense sound may obliterate, entirely or in part, the sensations of certain partial tones or components of any musical tone, and thus produce a profound change in its quality. In a large orchestra I have repeatedly witnessed the entire obliteration of all sounds from violins, by the deeper and more intense sounds of the wind instruments, the double-basses alone holding their own. I have also observed the sounds of the clarinets lose their peculiar quality of tone and consequent charm from the same cause. No doubt the conductor of the orchestra heard all his violins, ranged as they always are close around him, and did not perceive that his clarinets had lost that quality of tone on which *the composer* had relied for producing a special character of expression.

The function of the conductor of an orchestra seems to be threefold. First, to regulate and fix the time. Secondly, to regulate the intensity of the sounds produced by the individual instruments, for the purpose of expression. Thirdly, to give the

proper quality of tone or *feeling* to the whole sound of his orchestra, considered as a single instrument, by regulating the *relative intensities* of the sounds produced by the various classes of instruments employed. Now this third function, the regulation of relative intensities, has hitherto been discharged through the judgment of the ears of a conductor who is placed in the most disadvantageous position for judging by his ears. Surely he is not conducting for his own personal gratification, but for the gratification of his audience, whose ears stand in very different relations from his own in respect to their distance from the various instruments in action. Is it not time that he should pay more attention to his third function and place himself in the position occupied by an average hearer? This position would be elevated, and somewhere in the midst of the audience. The exact determination of its place would depend on various conditions which cannot now be considered. That the position at present occupied by the conductor of an orchestra has often allowed him to deprive his audience of some of the most delicate and touching qualities of orchestral and concerted vocal music I have no doubt, and I firmly believe that when he changes his position in the manner now proposed the audience will have some of that enjoyment which he has too long kept to himself. During the past winter, in the Academy of Music at New York, I fully confirmed all the foregoing surmises, by placing myself in different parts of the house to observe the different results, and my opinions were fully shared by others who have a more delicate musical organisation than I can lay claim to.

In large orchestras, these interferences of sonorous sensations are so multiplied and various as to be beyond our mental conception. By taking them up in detail, some general laws may, however, be evolved. But it will be impossible to formulate such laws until, firstly, we are in possession of a *quantitative* analysis of the compound tones of all musical instruments (that is, until we know the relative loudness of the partial tones of which they are composed at all parts of their compass), and secondly, we have determined throughout the musical scale the relative intensities of the sounds (of simple tones) when obliteration of the sensations of higher (simple) tones supervenes. The powerlessness of one sound to affect the sensation due to another sound lower than itself in pitch greatly simplifies this problem.

Quantitative analysis of the compound tones of musical instruments is now the great desideratum of the composer. It is only after we know the relative intensities of the components of typical musical tones used in orchestral performances, that we can so regulate their intensities as to give those qualities of sound which the composer desires to be heard. Thus, it at once becomes evident that the instruments used in orchestral music should be very differently constructed from those used for solos or quartets. In orchestral instruments certain *characteristic* upper partials (overtones, harmonics) should predominate, in order to find expression in the midst of other and graver sounds. Such orchestral instruments will therefore have exaggerated peculiarities in their qualities of tone, which will render them unfit to be played on alone, and uninfluenced by other orchestral notes. It is surely not hopeless to anticipate that empirical rules may be attained, which will guide the musical instrument-maker to the production of those special qualities of tone required in orchestral instruments. It is fortunate that the very phenomena of the interferences of sonorous sensations will assist in the much desired solution of the problem of measuring the intensity of a sound (simple tone), either when existing alone or as component of an ordinary musical (compound) tone. On this subject I am now engaged. It is evident (by way of illustration), that so far as concerns the measure of the relative intensities of sounds of the same pitch, this problem has already received the simplest solution by merely placing these sounds at various distances, and obliterating the sensations they excite by means of a constant and standard sound of a lower pitch. But I reserve a description of this work for a more formal publication.

NOTES

PROF. HUXLEY, who has recently left for America, has accepted an invitation from Prof. W. B. Rogers to attend the Buffalo meeting of the Association for the Advancement of Science, and also to deliver a course of lectures before the Johns Hopkins University. His stay, however, in the country will be but short.

THE Academy of Sciences of the Institute of Bologna announces an open competition for the Aldini Medal, to be awarded to the author of the memoir of greatest experimental and scientific value in galvanism. The medal is of gold, of the value of 1,000 liras, and is open to all works which profess to have extended our knowledge in any department of galvanism, and which may be sent to the Academy expressly for the competition, during the two years comprised between June 1, 1876, and May 30, 1878. Memoirs must be written in Italian, Latin, or French. The usual conditions of such competitions are to be observed, and memoirs should be sent in before the last-mentioned date, addressed "Al Segretario perpetuo dell' Accademia delle Scienze dell' Istituto di Bologna."

WE notice in the *Revue Scientifique* further particulars regarding the meeting of the French Association for the Advancement of Science, to be held at Clermont-Ferrand on the 18th inst. A list of the papers to be read is also given. This is a very useful arrangement for those who may anticipate taking part in the proceedings, and others, and might with advantage, we think, be copied in this country. In the group of physics and chemistry we note the following among the subjects to be treated:—Diffraction in optical instruments; new volumetric determinations of arsenic; new salts of bismuth; experiments made to determine if the ether is ponderable; observations in celestial and terrestrial physics in Japan and Siam (by M. Janssen); thermo-diffusive properties of cast-iron; the idea of unity in chemical and cosmic phenomena; the radiometer, &c. In the group of natural sciences:—Vichy waters, from a physiological and hygienic point of view; recent prehistoric discoveries in Medoc; animal heat; influence of the want of air and light in the streets and houses on health; functions of leaves and roots of plants in tropical countries; cure of paralysis by continuous currents; operations for cataract; the bite of vipers; ophthalmia in the North of Africa; proof of the existence of ferment-germs in the organism as in the air; a new aesthesiometer; production of phenomena of synthesis in plants; sporadic and endemic goitre in Puy-de-Dôme; on measles in beef and inermous tænia; resources of France as regards war-horses; various points in local archaeology, geology, palæontology, &c. In the group of economical sciences:—Teaching of living languages, from the economical point of view; remedies for phylloxera; depopulation of the country and emigration to America; workmen's dwellings and morality of France; economical consequences of the war indemnity, &c., &c.

THE storm of August 3 will be long remembered not only as being about the heaviest summer gale that has occurred for many years, but also as having been most disastrous to life and property among the fishing population. It broke out on the fishermen on the east coast just when their nets had been shot for the night at distances of twenty miles, and upwards, out at sea. The value of the nets lost at Aberdeen alone is estimated at 4,000*l*. The rate of the fall of the barometer being nearly an inch in twenty-four hours, the point to which it fell being about 29.0 inches at sea-level over a wide district in the north, the time during which it remained low, and the large and comparatively rapid rise which followed are rather the characteristics of our more marked winter storms. A storm of this nature is, therefore, deserving of a very careful investigation, chiefly with the view of ascertaining how far it might have been possible to have given the fishermen some intimation beforehand of its peculiarly destructive character.

In the *Bulletin International* of August 3, M. de Tastes relates some interesting particulars of a waterspout (*trombe*) which was observed near Tours, on May 25, 1876. It first appeared as a mass of whitish vapour against a background of